NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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AERONAUTICAL RESEARCH IN A TIME OF WORLD CRISIS

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After reading Leon Shloss' "Eighty Million Readers Can't be Wrong", my first reaction was that the title of his article about the Aviation Writers Association would have been more nearly correct if it had said, "One Hundred and Fifty Million Readers Can't Be Wrong". Upon your informed reporting of events in the science and art of flight everyone in this nation of ours must, practically speaking, depend for information. Yours is a man-sized job, one which is growing in complexity and importance. It is a responsibility, too, because in the performance of your job you are called upon to tell your customers, the 150,000,000 people of our country, not only the day-to-day happenings in the world of aeronautics, but also what those happenings mean, both now and for the future.

You who work here in the nation's Capital, are on the firing line where much of the aviation news is either developed or announced. It is up to you to tell America what is meant when the Congress appropriates billions of dollars for new military airplanes, when the CAB or CAA make basic policy changes, when the Military Services unveil new, high performance aircraft. Yes, even when we at the National Advisory Committee for Aeronautics do something in the field of research that the security regulations permit us to talk about.

That you take your responsibilities seriously is self evident. The fact that you are here today is indication of your willingness to invest time and effort to secure a better understanding of the over all aeronautical picture as well as to look for headlines.

By way of getting into our subject, let me discuss briefly the place of research in the aeronautical picture, and also who does what in the prosecution of that research effort. For many centuries men of vision labored to apply such scientific and engineering knowledge as was at their disposal toward the accomplishment of flight. In those labors, many contributed additional knowledge. Finally, this process of building aeronautical knowledge, bit by bit, was climaxed by the Wright Brothers whose efforts to fly succeeded in 1903, only after they had spent years in fruitful research and development work.

What has happened since then is, actually, only an enlargement of this structure of aeronautical knowledge. As soon as one set of seemingly impossible performance goals has been reached, even more difficult requirements have been imposed. Enlargement of the fund of knowledge in other fields has helped in the attainment of these progressively higher goals. Take, for example, the matter of jet propulsion. The idea itself goes back to the days of the ancient Greeks. But not until metallurgical technology made possible construction of a combustion machine that could operate at 1000° Fahrenheit, or so, was there much point in considering jet propulsion for airplanes. Even that would not have been enough, except that aerodynamically we had learned how to design airplanes that could fly 450 miles an hour, or faster, provided only sufficient power were available. At lower speeds, jet propulsion would have been so inefficient as to make the idea impracticable.

Such is our research task, the accumulation of the additional knowledge necessary to permit further advancement of the aeronautical frontiers.

It is, of course, necessary to have more than knowledge, especially when a product reaches a state of high performance such as has the 1951 airplane. There must be, in addition, a need for still further performance improvement, and the willingness and ability to pay the necessary cost of attaining that additional performance.

The fact that the airplane was readily adaptable to the requirements of waging war was responsible, in large measure, for the rapidity with which speed, range and altitude have been increased so enormously year after year. Twice, World Wars, and preparations for such terrible conflicts, have resulted in the expenditure of great amounts of scientific energy and money in behalf of aeronautical research and development, with military use the purpose. And today for a third time the step-up of research and development activity is for war reasons. In the United States we think in terms of resisting aggression rather than in terms of global conquest. Just the same, we had better make sure that at the very least, our military airpower, both qualitatively and quantitatively, is equal to that of the Communist nations.

Over the years a pattern has been worked out wherein the NACA has been primarily responsible for the conduct of fundamental or scientific research in aeronautics. This assignment as an active member of the nation's aviation team has not meant that no one else should perform research nor that NACA was restricted from completing work on some problem by testing its practical application. Numerous university groups engage in fundamental research. The NACA led in sponsoring aeronautical research by educational groups, and today supports almost a million dollars worth of such work each year. Support of research performed by universities is also forthcoming from the Military Services, who themselves conduct some research. And the aircraft industry, the airplane and engine manufacturers, conduct some of this kind of research.

But -- and this is important -- there is very definite correlation and coordination of this research effort, another part of NACA's job, which is done by the main committee and the 27 technical subcommittees. Because it is impossible to establish precise dividing lines to mark off the areas of interest of the partners in the aviation team, one might expect a considerable amount of duplication of effort. Fortunately such has not been the case. Instead, all of us who are involved in this aviation business have managed rather well to work together, respecting research as in the other parts of the total job, so that the resulting sum of our research effort has been valuable in helping the United States to maintain its air leadership.

The feeding, like so much pabulum, of the results of the experiences of other people into the mind does not automatically make a good aeronautical engineer or creative designer. The compression of the discoveries of other men into long sheets of neat tables may provide sufficient basis for the training of engineers in other fields, although even this I doubt, but handbook engineers are of little value in the aviation business today.

Nor is mere training in the knowledge and techniques of the aeronautical sciences, necessary though that be, insurance that the beneficiary of such training will make a good member of an aircraft or engine design team. The art of inventive application, of finding new answers to old and persistent problems, must be mastered. There must be added a precious ingredient, sometimes called ingenuity, to the formula of basic elements.

The next step involves another kind of research, usually called applied. This is when the theoretical facts and ideas are given the ultimate test. Will they work? If they do, wonderful. If not, the intelligent engineer rechecks his theories, tries new combinations of facts and ideas, on a sort of highly skilled cut-and-try basis.

At NACA we do some of this applied research -- not very much. The bulk of this acid-test treatment is conducted by the industry and the Military Services. There is yet another kind of activity which, in a sense is research. This is the process where a man looks at the possibilities available from research results, and then conceives and plans a product which will come closest to answering the requirements. I used the word, man. Perhaps I should have said, team of men, because in aviation today our airplanes and engines have become such complex things that the creative talents of a group of engineers have to be focused upon a job to realize the ultimate in terms of what can be accomplished.

What I have just outlined is the way things happen normally, or perhaps I should say ideally. The trouble with the word "normally" is that these days, nothing seems to be quite normal. If anything is normal these days, it is the state of continuing crisis which exists.

And so NACA isn't able to do business quite as it would like, spending say 80% of the time of its research personnel on our plotted program of scientific research and the remaining 20% on the conduct of specific investigations having to do with specific airplane or missile or engine designs. Instead we face the prospect, in the very near future, of finding ourselves in the position we were in 10 years ago, just before the United States was catapulted into World War II. The pressure on NACA at that time to concentrate on applying available scientific knowledge to the immediate improvement of airplanes scheduled for war production soon became so great that our basic research programs were cut and cut until they represented hardly 10% of our total work. The result was that we came out of that war with our barrel of research information just about empty.

We are trying very hard to avoid such a situation for several reasons. One is that we realize the entire free world depends on the United States for aeronautical leadership. Another is that we cannot look into the future and foresee how long it may be that the demands on NACA will be to perform great amounts of work conducting specific investigations, while the research barrel is emptied inexorably.

The way we hope to avoid a recurrence of the World War II situation is to continue our present program of scientific, fundamental research, while at the same time we step up our research-conducting capacity to enable us to do the also-vital investigatory work which leads to the speedy refinement of production airplane designs, the correction of troubles, the essential day-to-day improvement of current types. At least by comparison, we are in better position today to undertake such a double-barreled task than on the eve of World War II. Then we had one laboratory, and something less than six hundred research scientists and supporting personnel. Today we have three laboratories, and a little more than seven thousand research scientists and supporting personnel.

With the research equipment we now have, or are in the process of acquiring, we should have most of the essential tools with which to perform the research tasks to be done, both the fundamental and the specific improvement investigations. Inevitably we shall have to increase the number of our people, perhaps by a few thousand, but nothing like the way we had to expand a decade ago. Even so, this recruitment of research men is going to be a very difficult task, because the ones who have the 1951-type training in supersonic and hypersonic aerodynamics and electronics and all the other sciences that have a bearing on aeronautics are the young men who also are greatly in demand by industry, other government agencies and. . .General Hershey's draft boards. Time does not permit a thorough-going discussion of this problem, but it is a difficult one to solve to everyone's satisfaction. Speaking as impersonally and objectively as I can, I will note, however, that the world situation today is far too critical for the United States to be wasteful of this priceless, though perhaps youthful, brainpower.

The Communist nations can put into the field land armies much larger than those we can envision mustering on our side. Since the end of the fighting in

World War II, the Communists have been channeling a much larger segment of their total effort into the development and manufacture of new military aircraft, new tanks, new submarines, and other articles which are good for only one thing, fighting a war.

In the matter of brains, and what we do with our brains, we do have a potential very big edge over the Communist aggressor. Advantage, that is, if we make proper use of our brains, and of our industrial strength.

Let me talk for a couple of minutes about the way the work of the NACA ties in pretty directly with the planning and procurement of the Military Services in the field of aircraft and missiles. The start of such planning and procurement is, I suppose, a blueprint of what will have to be done to make possible the military commitments of the United States. Those commitments, of course, include defense of the continental United States and our other territories. They include also the support we have promised to other nations who wish to live in a free world. They include, right now, making good on such a promise, by virtue of our membership in the United Nations organization, made to the people of South Korea.

Next comes the writing of specifications for the airplanes and missiles which will be needed if we are to succeed in our commitments. There are many other things which also are needed, but it is airplanes and missiles with which the NACA has concern and responsibility. In the establishment of requirements, and the specifications to meet them, NACA counsels as to what kind of performance the manufacturers should be able to design and build into the models ordered.

Today they can make fighter airplanes that flirt with the speed of sound, using the 7000-pound thrust engines which are manufactured today. Perhaps tomorrow, on the basis of the new aeronautical knowledge built up since today's airplanes were conceived at the end of World War II, they can design and manufacture supersonic airplanes, ones that will have as well the added range and all the other qualities which the military need. Sometimes, perhaps, the industry must think that the counsel we give the Military services is altogether too optimistic, but we are ready to roll up our own sleeves to help make good on such beyond-the-horizon type of projects, and the industry has a way of translating possibilities into actualities.

Ordinarily, a number of manufacturers are invited by the Air Force or the Navy to submit design proposals outlining how they would go about providing a model which would satisfy the requirements set forth. These aren't a complete engineering job for the proposed new model, but usually they represent a good many hours of hard work by a good many of any particular company's best engineering brains. After the proposals have been evaluated, one or more of the ideas brought forth may look good enough to warrant going ahead on a prototype development contract.

Here, models are very often constructed, at the same time the mass of detailed engineering work progresses. One model may be, say, 1/16th scale, to be put in one of our high speed tunnels, to check such things as drag, directional and lateral stability, lift, and so forth. Another model might be nearly full-size, to be put in either the 40- by 80- Foot or 30- by 60- Foot full-scale tunnels at Ames and Langley, respectively. Now that we've had to go to fancy shape wings, with 45^{o} or more of sweep and thinness ratios that seem to rival those of razor blades, landing and take-off characteristics are an especially difficult problem. In the study of this problem answers that are as nearly full-scale as possible are most valuable. The work that is done here, you might say, is a kind of pre-flight evaluation. Engineers of the company whose models are in a tunnel would doubtless be on hand, and as the information is secured, it is possible that some modifications might be considered. In such a case, and I would like this to be clearly understood, it would be the company engineer who would decide what changes should be made. Doubtless he would welcome assistance in solving whatever problems might be involved, and we would be as helpful as possible. The point I make is that NACA isn't in the design business, and has more than enough of its own kind of work to do to think of getting into the design business!

Next we come to the time when all the preliminary work has been done and the manufacturer is ready to roll his shiny new airplane out onto the ramp for its first flight. Any changes which laboratory studies showed to be important have been made. The airplane is ready to go. And fly it does, quite nicely for a maiden flight.

If you think the job is finished for anyone, then, let me tell you the story in terms of one of the best airplanes to be built during the last war. Up to and through the prototype stage, the manufacturer invested something like a million and a half engineering man hours in this airplane. During this same period, NACA spent almost a hundred thousand engineering man hours on the airplane.

During the period this airplane was in production -- a good many of this particular model were built -- the manufacturer spent almost five million man engineering man hours to secure improvements, to make the airplane a lot better than the prototype. And NACA during that same period spent approximately a half-million engineering man hours to the same end.

To say it another way, and the example I have just given is not out of the ordinary, up to three times the amount of engineering man hours invested to make it fly is likely to be spent on an airplane, after the prototype has been flown!

The number of engineering man hours which will be spent in the future, both up to the prototype stage of an airplane and beyond, is likely to increase very substantially. This is because, in terms of effort and money, it is becoming more and more expensive to gain faster speed, or longer range, or any of the other improvements we still seek from our aircraft. If it were on a basis of commercial return, I doubt very much whether we could expect to continue spending money at the current rate. Perhaps one could go farther and doubt whether such expenditures would be continued for any reason except the cold fact that we dare not let the Soviets get ahead of us.

In the missile field -- and so far as missiles are concerned, the security curtain is drawn even tighter than for man-carrying airplanes -- the NACA is active too. Here we are working on aerodynamic problems and propulsion problems especially. At the speeds missiles can go today, and at the near-hypersonic speeds they will be flying tomorrow, aerodynamic problems, such as stability, maneuverability and lift, are extremely important. They are problems about which -- in these speed ranges -- we know not nearly enough. Here we are having to explore a new field, a hypersonic aerodynamics field! Similarly, in the field of powerplants for missiles, there are many, many problems which will have to be solved before we can expect to build missiles that will do half the tasks our military requirements people request. There are many other complex and perplexing problems associated with missiles, but most of them are worries of someone else. If we're able to provide helpful answers concerning aerodynamics and propulsion, we will feel we have done reasonably well.

Last year, the Congress appropriated $75,000,000 to be used in the construction of three large, supersonic tunnels at our NACA Laboratories. They are to be used for development and evaluation purposes by manufacturers, and are part of the Unitary Wind Tunnel Plan. They will be operated by NACA in the accomplishment of this work. The action last year was the result of proposals made soon after the end of the last war.

The other day I was asked whether any of these tunnels had been put into operation yet. For a moment, I was taken aback, because actually, it is only now that initial construction of equipment for the first of these three tunnels has begun. Contracts are being negotiated just now for construction of the various parts of the two others, and it will be two years or so before any of the three tunnels is put into useful work.

In thinking over this question -- had any of the Unitary Wind Tunnel Plan tunnels started up yet -- I realized that it was a natural one after all, at least on the basis of the little information that is generally available, and so I thought I'd discuss this in the last minute or two that is left today.

The $75,000,000 we got from the Congress was a lot less than we had originally estimated these three tunnels would cost. Actually, our figures which were pretty realistic were $102,000,000. The higher figure was based, very much as are cost estimates of new airplanes still in the proposal stage, on estimates. It was not based on completed tunnel designs, because such designs -- and every tunnel is specially designed to help in the performance of a different area of research investigation -- are expensive, and there would be no point in spending a quarter of a million dollars or so designing three such tunnels until we knew we would get the money to build them.

Let me try to say it in terms of home building. Suppose you own a lot and want to put up your own home. You tell an architect about what you want, and about how much you want to pay. These first estimates are based on average costs, so much a cubic foot of room, or so much a square foot of floor space. The architect, using these figures, roughs out the design, and it suits both you and your wife beautifully.

Next you go to the bank and work out your financing, including the building loan and all the rest. Only after this has been done, and you've given the architect a firm contract does he complete his detailed design work. After that, when the builder has given you a rock bottom price that is a good five thousand over the maximum you can pay, you go back to your architect and take out the pine paneling in the expansion attic and the fancy flooring in the game room part of the basement. Probably, you wind up leaving both attic and basement unfinished for the day when you try your luck at home carpentering.

On the basis of firm commitments, you notify your rental agent that you'll be letting the lease run out as of June 1, and begin the business of hiring a moving van and getting the utilities installed. Then, the following September 1, you move the family back from Gramma's where they've had to stay the summer while you've bunked in at the "Y". And the little dream house you have for yourself won't really be finished until the first of the year. The final blow usually is the second trust you get to cover the rise in costs.

Building big wind tunnels is like that, only worse. We can't go to any of the big electric companies and say, please take a 200,000 horsepower motor down off the shelf and deliver it by five o'clock. Instead we have to approach them, almost obliquely, and tell them that we know they're big enough to accept the challenge to design and manufacture such a motor, which is perhaps twice the size of anything they've ever tackled before, and not only that, but can do so within the price range that we can pay, and within the time limit we've estimated.

It is the same way with the giant compressor that the motor will turn, to whip up the supersonic flow through the tunnel. Ditto the air dryers, the cooling equipment, the control panels, the instrumentation, and all the rest. While all this is going on, our engineers -- who have staked their own reputations on the belief that the new, radical design will permit getting more precisely accurate information than ever before at higher speeds than before from bigger models than we've ever before been able to put into a supersonic wind tunnel -- our engineers are cultivating ulcers checking and rechecking their computations.

That's why the new wind tunnels that we got money for almost a year ago aren't running yet.

But tough as that job is -- and now I'm repeating one thought by way of closing -- all of us wish we could produce scientists and other research personnel on such a manufacturing basis. Because no matter how successful we are in designing and building these new research tools, they'll be of little good unless we have the trained and talented brainpower to make proper use of them.

We've got a big collection of problems. Perhaps that's why so many of us are happy in our work.

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